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PDES APPLICATION PROTOCOL SUITE FOR COMPOSITE (PAS-C)

SCOPING AND BENEFITS CRITERIA
VOLUME 1 - EXECUTIVE SUMMARY AND OVERVIEW

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NOTICE

This technical report has been reviewed and is approved for publication.

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13. ABSTRACT (Maximum 200 words)
THIS DOCUMENT IS PART OF A TWO VOLUME SET THAT EXPLAINS THE METHODOLOGY AND RESULTS OF THE PAS-C PROGRAM'S SCOPING AND BENEFITS ANALYSIS. VOLUME 1 (PASC007.01.00) IS AN OVERVIEW OF THE PAS-C PROGRAM, THE RESULTS OF THE PROGRAM'S EFFORTS TO DATE RELATIVE TO SCOPING THE PAS-C APPLICATION PROTOCOL SUITE, A SUMMARY OF THE BENEFITS THAT COULD BE REALIZED ON THE PAS-C DEMONSTRATION PARTS, AND A SUMMARY OF THE PROGRAM'S SUCCESS CRITERIA. VOLUME II (PASC008.01.00) GIVES THE DETAILS OF THE DATA THAT IS PRESENTED IN VOLUME 1.

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TD	Technical Data
TDP	Technical Data Package
USAF	United States Air Force
VIG	Vendor Implementation Group
WG	Working Group

FOREWORD

This document is part of a two volume set that explains the methodology and results of the PAS-C Program's Scoping and Benefits Analysis. Volume I is an overview of the PAS-C Program, the results of the Program's efforts to date relative to scoping the PAS-C Application Protocol Suite, a summary of the benefits that could be realized on the PAS-C demonstration parts, and a summary of the Program's Success Criteria. Volume II gives the details of the data that is presented in Volume I.

1 PAS-C PROGRAM SUMMARY

There are many challenges in developing standards that determine such items as formats, methodologies, and organization for data exchange, especially in the realm of emerging technology areas such as composites. One of the major managerial challenges in creating a PDES Application Protocol Suite is to find the appropriate mix of elements where Government, industry, and vendors can contribute and benefit. The greatest technical challenge is creating a development strategy where many diverse informational views pertaining to one piece of information are identified and then similarities distinguished to make a core of generic sharable information. The ability of the PDES Application Protocol Suite for Composite (PAS-C) Program to quantitatively identify, then balance these diverse managerial and technical challenges to achieve a usable, do-able, and implementable portion of the composite part information exchange needs is the focus of this document.

1.1 Background

In the business environment of the future, data and information generated from product concept through design and manufacturing to disposal will be accessed and stored in an internationally accepted standard data structure. This data structure, STEP, will provide an unambiguous computer interpretable representation of the physical and functional product characteristics which design, manufacturing, and support systems can accept and use.

STEP is built on a concept of intelligent information structures designed to contain comprehensive product data including geometric information in a way that both the parts and drawings can be generated. STEP is being developed in an incremental manner which allows for the development and utilization of useful subsets of the overall family of STEP Parts.

STEP will provide the ability to:

- exchange product information in electronic form between different suppliers' tools,
- electronically interchange product information between suppliers, subcontractors, prime contractors, and the customer,
- provide for concurrent engineering through information sharing,
- create data once, use the data many times for many purposes,
- maintain consistent data across life cycle applications,
- enable greater automatic handling of product data.

An application protocol (AP) defines the context for the use of product data and specifies the use of the standard in that context to satisfy an industrial need. APs are referred to as the implementable parts of STEP.

PDES (Product Data Exchange using STEP) is the U.S. organizational activity that supports the development and implementation of STEP. It will act to ensure that the requirements of U.S. industry are incorporated into STEP and will provide U.S. industry with a methodology for the implementation of STEP standards. STEP will provide a complete, unambiguous, computer interpretable representation of the physical and functional characteristics of each unit of a product throughout its life cycle. As a standard method for digital product definition, STEP will enable communications among heterogeneous computer environments, enable integration of systems which support design, manufacturing and logistics functions/processes, and support automatic, paperless updates of product definition documentation. It is a major Computer-aided Acquisition and Logistic Support (CALS) building block.

1.2 PAS-C Overview

The PAS-C Program addresses two critical national technologies - composites and product data exchange tools. Each of these emerging technologies exist in a dynamic environment. Not only are there fast paced technical changes, but there are also frequent changes in the organizations involved in formulating the technology. PAS-C has developed a set of approaches that will maximize the success of the PAS-C Program and minimize the risks associated with the changes that are on going in both the technology and the environment.

The awareness of the current PDES/STEP and composites environments and the ability to function effectively within those environments is critical to the success of the PAS-C Program. Composite information contains unique requirements, with both detail and assembly, and with material and process information closely intertwined. The complexity and volume of product data associated with a composite part is usually much greater than other types of parts.

The PAS-C Program has structured a unique technical approach for developing an Application Protocol Suite (AS) for composites. This Framework/Building-Block (FW/BB) methodology is designed to address the integratibility, extensibility and nesting of Application Protocols (APs). The building blocks shown in Figure 1 can be reused on multiple APs. After validation on PAS-C, this methodology will be a proven technique to implement Application Protocol Suites.

The approach being used in conducting the PAS-C Program is designed to maximize the consensus within the communities (composites, standards, software applications and government) with regard to the following PAS-C products: Composite Needs Analysis, PDES State-of-the-Art (SOTA) Assessment, PDES Voids, AS Development Strategies, AS Test and Demonstration Criteria, Application Reference Models (ARMs) and Application Interpreted Models (AIMs). Achieving a consensus in these areas is important to the approach. An integrated set of activities is being utilized to achieve the greatest consensus possible in the least amount of time. A goal of the PAS-C Program is to stimulate vendors to develop a set of software applications that will be used by the composites manufacturers. Several of the most important activities in the approach are described briefly:

- The IPO Composites Committee and other IPO/ISO committees to review and

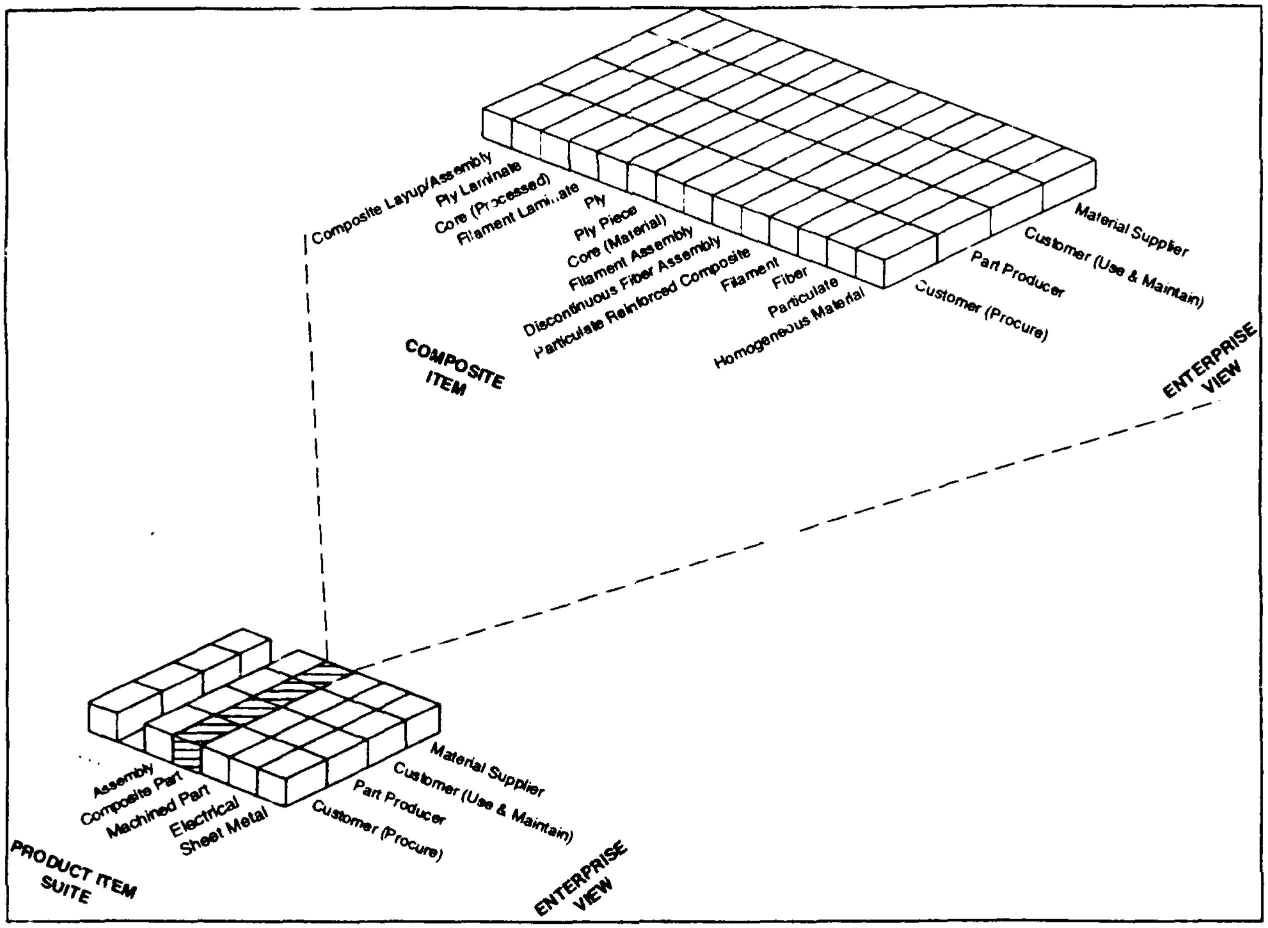

Figure 1 Framework/Building-Block Structure for Composites Application Protocol Suite

approve the SOTA, Application Activity Models (AAMs), ARMs, and AIMs,

- The Framework/Building-Block methodology for developing Needs Analysis and models,
- Industry Review Board and Vendor Implementation Group participation in developing the priority of voids, AS Strategy, Test and Demonstration Criteria and the demonstrations,
- Design of a risk management strategy based on consensus building among the industry, vendor, government and standards communities,
- Technology transfer centered on achieving concurrence with and ownership of the AS results of the program throughout all communities.

The Air Logistics Centers (ALCs) are being encouraged to participate at the onset of the program. Through the Vendor Implementation Group (VIG), vendors will understand the business case and be encouraged to develop commercial tools. The Industry Review Board (IRB) provides a forum for the Air Force, Industry, and the PDES community to review the progress of the PAS-C Program and provide guidance.

The PAS-C Program schedule consists of completing the PAS-C Program within 52 months and is divided into three phases. Air Force approval is required before commencing effort on Phases II and III. This schedule contains a 12 month duration for Phase I, a 24 month duration for Phase II, and a 12 month duration for Phase III. This is followed by a 4 month period for conducting the Industry/Government Debriefing and final report preparation and review.

Figure 2 provides the overall program roadmap. Output from each Phase provides the needed input to the next successive Phase. The results of the Needs Analysis tasks performed in Phase I form the basis for developing the Application Protocol Suite. Three Application Protocols are scoped for the AS developed in Phase II. The schedule reflects the proposed development times for the Application Reference Model (ARM), Application Interpreted Model (AIM), and Testing Criteria for each of these Application Protocols. Phase III will use the AS developed in Phase II for a demonstration.

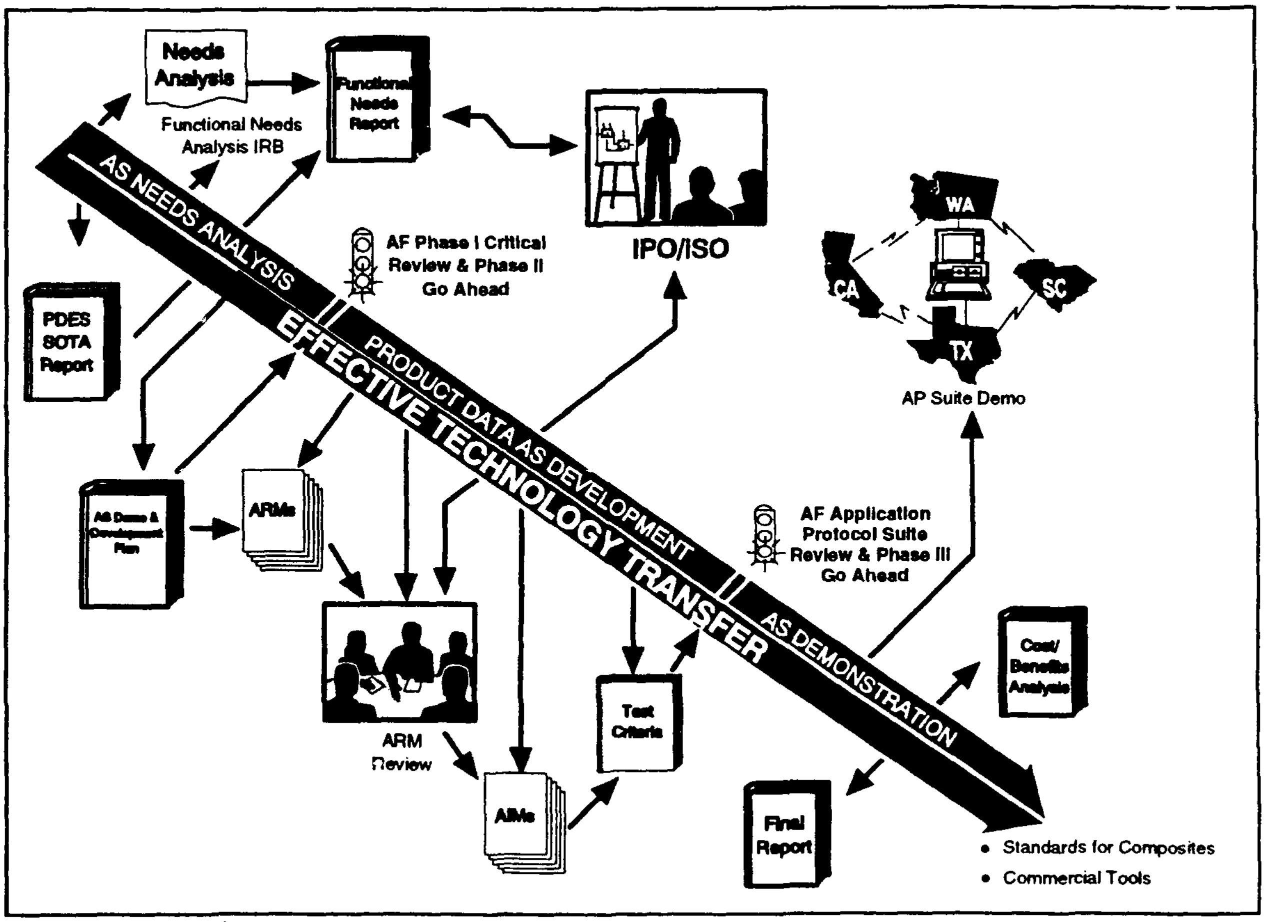

Figure 2 PAS-C Program Roadmap

1.3 Program Organization

The PAS-C Program organization is shown in Figure 3. An important part of the PAS-C Program is the Industry Review Board (IRB) which is comprised of both industry and government representatives (Composites Automation Consortium, Inc., DARPA, General Motors, IPO, Lockheed, Navy, Northrop and Universal Technologies). The IRB convenes at Air Force scheduled reviews to receive progress reports of the effort and offer guidance to the program team. The team is also aided by the Risk Management Board, made up of senior executives from the participating companies. This board meets periodically to provide advice on quality and risk management.

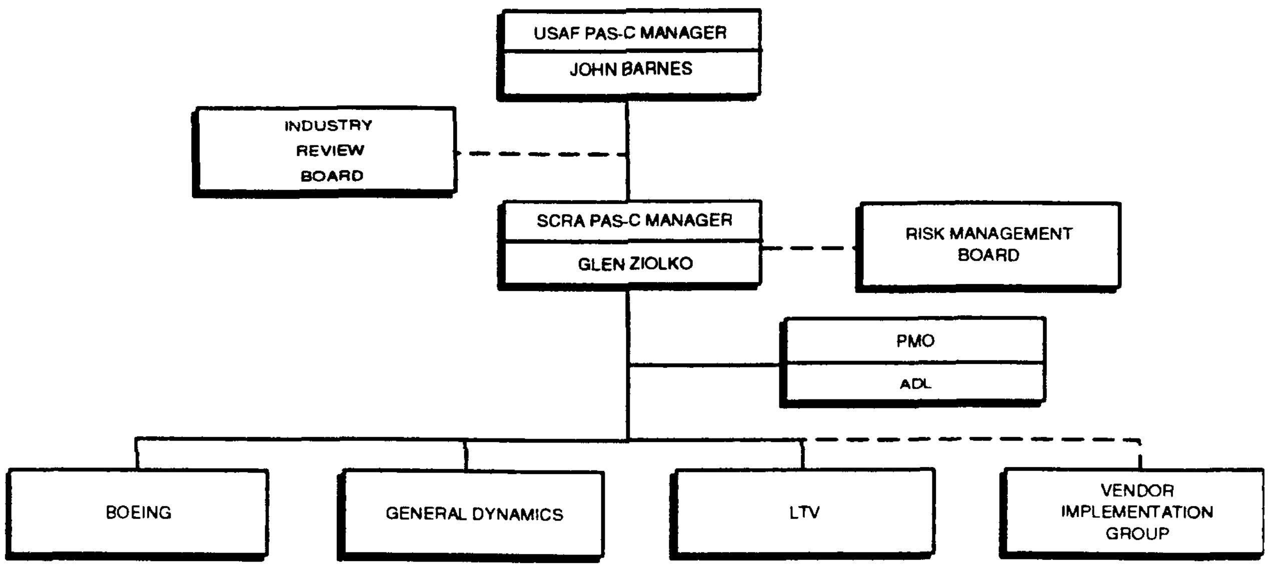

Figure 3 PAS-C Program Organization

Another important aspect of the program organization is the Vendor Implementation Group (VIG). This group will interact with the team continuously to insure that the development of implementation tools (e.g., translators) is incorporated into its business strategy. The AS development tasks are performed by a team of composites and PDES/STEP experts from Boeing, General Dynamics and LTV.

1.4 Program Status

Figure 4 is an overview of the tasks and the milestones that were achieved in Phase 1 of the PAS-C Program. This section provides an overview of the analysis, tools, and methodologies that were utilized in the completion of the requisite tasks. The methodology shown in Figure 4 forms the basis for the PAS-C AS scope.

The blocks in Figure 4 are the milestones that were achieved. The lines indicate the flow of data

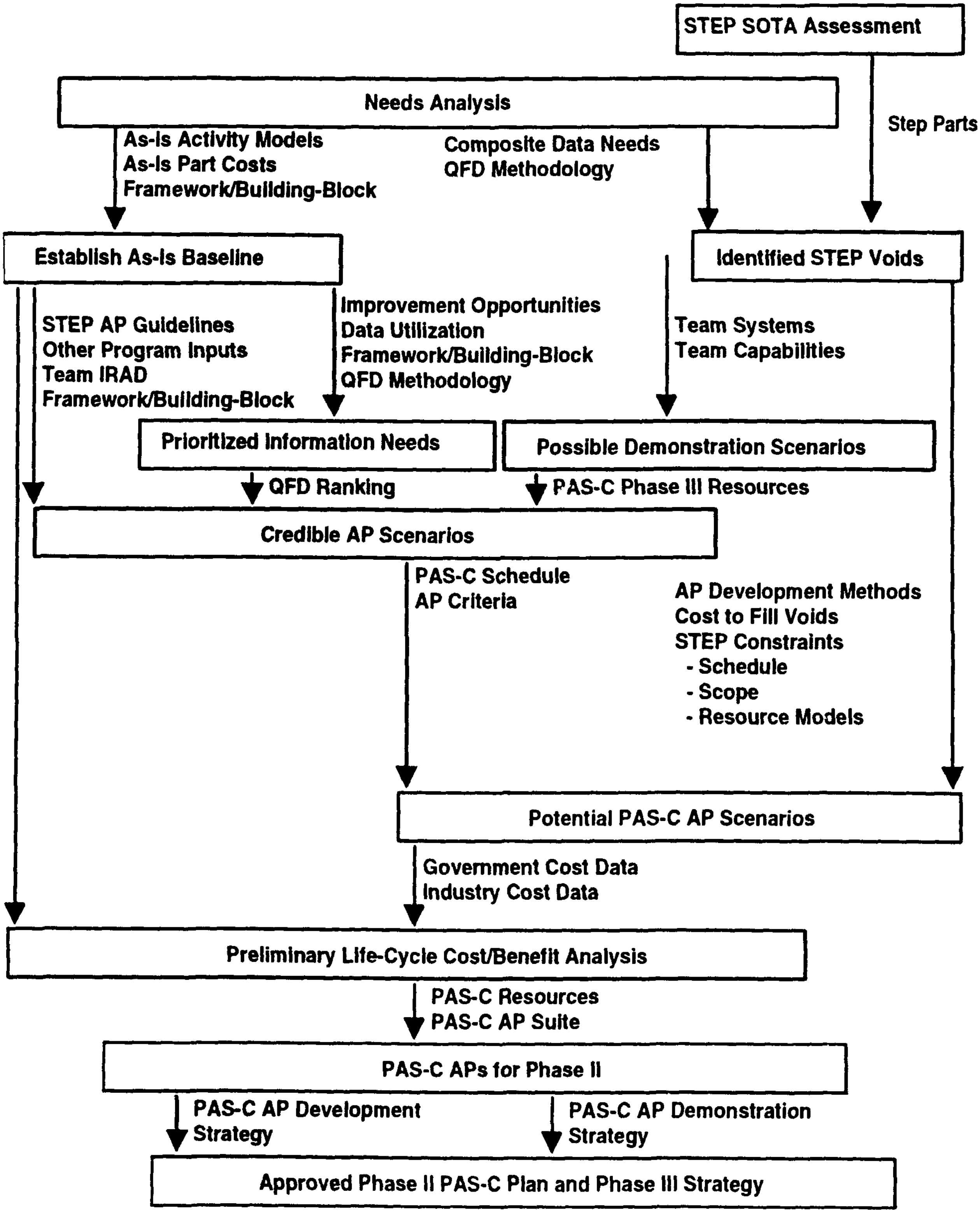

Figure 4 PAS-C Phase I Analysis

between the milestones and the tasks that added value to the data during the Program. The milestones are:

- Needs Analysis - This is the needs analysis documented in the *Functional Needs IDEF0 Activity and Information Needs for the PAS-C Program* [1] and the cost data that was collected for the demonstration parts.
- STEP SOTA (State-of-the-Art) Assessment - This is the activity that recorded the current status and maturity of STEP which is documented in the *PDES State-of-the-Art (Sota) Assessment for the PAS-C Program* [5].
- Establish AS-IS Baseline - This is the AS-IS baseline for the cost/benefit analysis (CBA). It consists of the way the PAS-C Team does business today [1], the methods that the Team utilizes to achieve the desired results in the respective Team's company, and the costs associated for the respective demonstration parts [2]. The AS-IS Baseline resulted from the needs analysis activity model developed earlier in the program.
- Identified STEP Voids - This activity represents the correlation of the information needs identified in the PAS-C Program against the current STEP Parts and an identification of the voids in the STEP Parts. This was done with the QFD methodology.
- Prioritized Information Needs - This is a prioritization of the information needs from an analysis of the activity model by: 1) Information utilization within the respective activities, 2) Projected reduction of labor hours for respective activities with a PAS-C type implementation, and 3) Cost to the PAS-C Program to resolve the information need within the PDES/STEP environment. This analysis was done utilizing an objected oriented DBMS and the QFD methodology.
- Possible Demonstration Scenarios - This is an evaluation of PAS-C Team Companies current automated applications and which systems could possibly be utilized for a PAS-C demonstration in Phase III. This also includes identifying potential opportunities for software and hardware vendors to participate.
- Credible AP Scenarios - These are possible AP scenarios that could be achieved in a composites arena for data exchange. These are enumerated relative to different aspects of the business with a FW/BB philosophy. They were developed from an analysis of the AS-IS Baseline, inputs from other Program's analysis (i.e., SPARES, ATMCS, ATF), the company methods that the PAS-C Team is currently utilizing (or projected to utilize), and the STEP AP guidelines.
- Potential PAS-C AP Scenarios - This is an analysis activity conducted to determine what the PAS-C Team could do within the limitations of: 1) The PASC schedule, 2) The STEP environment, and 3) The goals of the PAS-C Program (i.e., AP Suite Criteria). The results of this activity were candidate AP scenarios that PAS-C could develop.
- Preliminary Life-Cycle Cost/Benefit Analysis (LCC/CBA) - This activity included applying cost data against the potential PAS-C AP scenarios that rated highest in the AP criteria to determine what the three APs would be for the Program to develop. The PAS-C Program did a preliminary LCC CBA for each of the

scenarios to determine which had the highest potential payback. A LCC CBA could not be done for each potential AP scenario due to the resource constraints. This preliminary LCC CBA will be utilized in the development of the final LCC CBA for the Program in Phase III.

- PAS-C APs for Phase II - These are recommended APs considering the CBA, the PAS-C AP Suite Concept, and the PAS-C Program's resources.
- Approved Phase II PAS-C Plan & Phase III Strategy - These plans and strategies are recorded in the document *Development and Demonstration Plan for the PAS-C Program*, reference [3].

The following subsections summarize the documents that have (or will be) delivered in Phase I of the PAS-C Program. It is the intention that Figure 4, along with the following documents and Volume II of the Scoping and Benefits document, will give the reader an understanding of the involved analysis that the PAS-C Program performed to come up with an appropriate AS.

1.4.1 PAS-C Information Needs Analysis

The PAS-C Information Needs Analysis was chronicled in two documents: *Functional Needs Report for the PAS-C Program* [4] and the *Functional Needs IDEF0 Activity and Information Models for the PAS-C Program* [1]. The Functional Needs Report preceded the Information Needs Report by several months and was used as the basis for the development of the Information Needs analysis.

The challenge for the PAS-C Program in collecting and analyzing the composites data needs was in developing the gathering process into a structured, achievable task that provided usable/reusable knowledge. What has been lacking in previous needs analyses was an overall methodology that allowed for the informational needs of all aspects of composite parts to be captured. The PAS-C Program introduced a generic structure for composite part information that facilitated this overall methodology. This overall methodology also managed and utilized existing needs gathering methods to capture existing composite needs analyses while allowing the reusability of information. The difficulty in establishing this overall methodology was the lack of standardization of terminology and informational constructs throughout industry.

The *Functional Needs IDEF0 Activity and Information Models for the PAS-C Program* [1] records the standardized terminology, the functional activities within the life-cycle of a composite part, and the information that is exchanged between and within these functional activities. The functional activities addressed include Analysis, Design, and Build. The document also defines the part families used to scope the functional activities, the functional activities themselves, and the building-blocks used to define the information requirements.

1.4.2 State-of-the-Art Assessment

The *PDES State-of-the-Art (SOTA) Assessment for the PAS-C Program* [5] assessed the ability of the applicable Parts of the STEP standard to achieve the goals of the PAS-C Program. The assessment was restricted to those areas that may impact the achievement of the PAS-C goal of developing an Application Protocol Suite (AS) for composite parts.

The PAS-C SOTA assessment stated that the informational content of the critical Parts for PAS-C appear to be stable enough to achieve the goals of PAS-C. However, changes to Parts 41 (Fundamentals of Product Description and Support), 42 (Geometric and Topological Representation), 43 (Representation Structures), 46 (Visual Presentation), and 101 (Draughting) during Phase II could impact the schedule and scope for Phase II, depending upon the extent of the changes.

1.4.3 Functional Needs/State-of-the-Art Comparison

There were three major objectives for this document: (1) the refinement of the functional needs that were documented in the *Functional Needs IDEF0 Activity and Information Models for the PAS-C Program* [1]; (2) the correlation of these composite part information exchange needs to the available resources in the PDES/STEP information models; (3) the prioritization of the STEP information exchange capability voids identified during the comparison. The overall methodology for performing the refinement of the needs analysis, and for creating and interpreting the data was the Quality Function Deployment (QFD) technique House of Quality (HoQ). This resulted in the assessment of information needs for PDES/STEP and the PAS-C resource requirements to satisfy those needs.

1.4.4 Development and Demonstration Plan

The *Development and Demonstration Plan for the PAS-C Program* [3] presents the constrained, orderly plan to develop an Application Protocol Suite for composites and demonstrate that the Application Protocols in the AS satisfy the stated needs for the requisite APs. The PAS-C Team sample part set, and the government part set, will be the parts used to validate the PAS-C APs in the AS. The plan covers Phases II and III of the PAS-C Program.

The development plan presents the description of how an Application Protocol Suite consisting of three Application Protocols will be developed. This description includes detailing the individual tasks necessary to develop an AP. These tasks are then scheduled and resources allocated to accomplish them. This plan also includes how these Application Protocols will be integrated into a suite such that they are consistent with each other and will be capable of exchanging the information that is common between them.

The demonstration plan presents how the PAS-C team will demonstrate the use of this Application Protocol Suite in a simulated real world environment. This demonstration will be for the three parts selected earlier in the program plus an additional part furnished by the Air Force. The demonstration will include applications which represent work which would occur in the environments of prime contractor to subcontractor, between teaming partners, and prime contractor to Air Force. This demonstration plan includes involvement of software and hardware vendors through the program's Vendor Implementation Group (VIG).

2 SCOPING AND BENEFITS SUMMARY

This section explains the analysis performed in determining the APs for the PAS-C Program. Figure 4 provides the overall view of the PAS-C Phase I analysis with the flow of activities and the milestones associated with them.

2.1 Precursory Analysis

The initial view of data exchange gives a very vast set of credible data exchange scenarios. Even when the arena of composites is just considered, there are still an overwhelming number of credible data exchange scenarios that PAS-C could consider. Therefore, the PAS-C Program has identified three application protocols for data exchange. These analyses will identify the optimal content of these APs and show the highest potential payback for the life cycle of composites data.

In order to properly document the optimal content of the three APs, the following steps were completed:

- Identify the appropriate data exchange scenarios that occur within each of the three AP functional areas. This information was obtained from the *Functional Needs IDEF0 Activity and Information Models for the PAS-C Program*, reference [1].
- Define the proper analysis criteria to be used to evaluate each of the data exchange scenarios. These are summarized in Section 2.3 of this document and detailed in Section 4 of Volume II of this report.
- Evaluate each of the analysis criteria for all of the data exchange scenarios. A summary of this analysis is contained in Section 2.3 and detailed in Section 5 of Volume II of this report.
- Perform Life Cycle Cost Analysis on the data exchange scenarios that achieved a high value on the AP Criteria Analysis evaluation. A summary of the LCC Analysis is contained in Section 2.4 and detailed in Section 6 of Volume II of this report.
- Summarize the results of analyses and generate a listing of the suggested content of the three APs. Section 3 contains a description of the content of the APs.

The phases of a composite item's life cycle that the three APs will focus on are:

- Design to Analysis,
- Design to Manufacturing, and
- Design to Support.

The selection of these three life cycle phase were based on fulfilling as much of the PAS-C;s number one objective as possible. The PAS-C Program objectives and success criteria are located in Section 4. The design function appears in each of the life cycle phases because this is where the hub of the product data exchange took place that satisfied the requirements of a Level 3 production drawing package.

2.2 Identification of Credible Data Exchange Scenarios

The PAS-C analysis that identified potential STEP data exchange scenarios was fairly extensive and driven by the needs of the respective functional areas. Eleven design <--> analysis data exchange scenarios were identified, twelve design <--> manufacturing data exchange scenarios were identified, and fifteen design <--> support data exchange scenarios were identified. These data exchange scenarios are enumerated in Volume II and were each evaluated in terms of applicability to the PAS-C Program before becoming a candidate for inclusion into an application protocol by PAS-C.

2.3 Application Protocol Criteria Analysis

Each of the data exchanges were either combined or split up to evaluate as credible application protocols. Seven criteria were used to evaluate each credible AP based on the information content of the data exchanged, as well as, the origin and destination of that data. The criteria and its associated weighing factor are as follows:

- Technical Risk (30) - Evaluate the complexity and quantity of the data and determine if it is within the scope of PAS-C and/or STEP. Also determine if it is reasonable to complete an AP with this data content within PAS-C resource targets.

- Implementation Impact (20) - Determine if there is a need within government and/or industry for this AP and if it is likely that vendors would include this AP structure in commercial systems. Also evaluate the impact of changes to existing systems to utilize this AP structure.

- Performance (10) - Determine, if this AP were implemented, the degree to which it would satisfy the needs within industry, government, and specific companies. Evaluate the cost effectiveness of this AP and whether it meets the stated objectives of the PAS-C project. Also determine if the granularity is suitable for an AP.

- Schedule Risk (10) - Evaluate to what degree the development of this AP is under the control of the PAS-C project (vs. being developed by others).

- Benefit to US Industry (10) - Determine if the AP would support teaming relationships between companies sharing data from different points in the life cycle and/or typical sub-contracting data exchanges.

- Benefit to Air Force (20) - Determine if the AP satisfies needs in the areas of re-procurement, repair, and modifications.

- Cost of Void Elimination (Go/No Go) - Determine if development of this AP is reasonable under the PAS-C process or could present an avenue for extensions or spin-off projects.

The following is a listing of the data exchange scenarios that received the highest criteria values and the associated application protocol:

Design to Analysis AP Potential Data Exchanges

AP 1.0 Design & Design Allowables to Detail Analysis and Results Exchange

AP 1.1.1 Static Loads Analysis to Dynamic Analysis

AP 1.1.4 Thermal Analysis to Static Stress Analysis

AP 1.1.5 Mass Properties Analysis to Static Stress Analysis

Design to Manufacturing AP Potential Data Exchanges

AP 2.0.1 Geometry Layouts & Models to Tool Design

AP 2.0.2 Geometry Layouts & Models to NC Programming

AP 2.0.3 Parts List Data to Manufacturing Planning

Design to Support AP Potential Data Exchanges

AP 3.0.1 Design Technical Data Package & 3-D Models to ALC Detail Part Production

AP 3.0.6 Design Technical Data Package & 3-D Models to ALC Assembly Production

AP 3.0.10 Design Technical Data Package & 3-D Models to ALC Repair

These data exchanges were then run through the Life Cycle Cost Analysis for the three PAS-C demonstration parts.

2.4 Life Cycle Cost Analysis

The preliminary Life Cycle Cost/Benefit Analysis (LCC/CBA) of implementing a PDES Application Protocol Suite for Composites (PAS-C) within Industry and Government was done for the highest rated AP data exchanges from the Application Protocol Criteria analysis. This preliminary LCC analysis gave an indication of the order of magnitude savings that could be realized within a typical PAS-C AP implementation. The results for the respective evaluations were done on a per AP area basis so that the comparisons were equitable. The results were indicative of the kind of payback that can be expected in a PAS-C AP implementation situation and are not absolute. The numbers were indicators of the benefit and do not account for many factors such as system development, system maintenance, and system implementation. They were only utilized to prioritize the different aspects of scope within the APs for the respective areas.

It must be kept in mind that the following reductions are for the specific PAS-C demonstration parts and the cost data was taken from the respective company's records. This is not the family of parts, but the specific PAS-C demonstration parts that were selected. If the LCC analysis was run against a different part in the same family, different results could result due to change activity, company methodology, etc. Furthermore, the AS-IS hours on each of the parts would probably be different for each of the PAS-C companies, if the respective part(s) were designed and analyzed at the respective location.

2.4.1 Design to Analysis

The preliminary LCC analysis for the candidate APs that scored high on the Application Protocol Criteria for Design to Analysis (i.e., AP 1.0 - Design & Design Allowables to Detail Analysis and Results Exchange, AP 1.1.1 - Static Loads Analysis to Dynamic Analysis, AP 1.1.4 - Thermal Analysis to Static Stress Analysis, and AP 1.1.5 - Mass Properties Analysis to Static Stress Analysis) indicates that the greatest opportunity in this area is for AP 1.0 in terms of reduction in hours and in reduction in effort as a percentage of labor hours. None of the APs that were evaluated for analysis had Engineering Change Notice (ECN) and/or Engineering Change Proposal (ECP) activity factored into the analysis. Therefore, the reductions could be greater if these were factored into the reductions. For the Design to Analysis area, AP 1.0 is recommended.

2.4.2 Design to Manufacturing

The preliminary LCC analysis for the candidate APs that scored in the upper portion of the Application Protocol Criteria for Design to Manufacture (i.e., AP 2.0.1 - Geometry Layouts & Models to Tool Design, AP 2.0.2 - Geometry Layouts & Models to NC Programming, and AP 2.0.3 - Parts List Data to Manufacturing Planning) indicates that the greatest opportunity in terms of reduction in hours is AP 2.0.1. The AP that shows the greatest reduction in terms of percentage effort are for AP 2.0.2. Since the potential payback in terms of labor hours is significantly greater and the difference in percentage reduction is not that great, AP 2.0.1 was recommended.

2.4.3 Design to Support

The application of the PAS-C Application Protocol Criteria to the candidate APs in the Design to Support areas did not make as clear of a differentiation between the respective APs. The three highest candidate APs (i.e., AP 3.0.1 - Design Technical Data Package & 3-D Models to ALC Detail Part Production, AP 3.0.6 - Design Technical Data Package & 3-D Models to ALC Assembly Production, and 3.0.10 - Design Technical Data Package & 3-D Models to ALC Repair) showed that AP 3.0.1 gave the greatest benefits from the potential benefits that were obtained from data from other programs. Even though these values were not obtained directly from PAS-C efforts, they are believed to be indicative of the potential savings that could occur with the application of AP 3.0.1. The savings for the APs in this area are believed to be potentially greater because of the availability of limited cost data. This is because the complexity of composites data is much higher than typical part cost data that was available.

2.5 Application Protocol Expected Benefits

Table 1 shows the results of the preliminary LCC analysis when applied to the three PAS-C demonstration parts. These results were formulated by running each demonstration part through the LCC analysis evaluating each of the application protocols (Design to Analysis, Design to Manufacturing, and Design to Support). The values in Table 1 reflect the summation of the LCC analysis results from each of the three application protocols when only their highest payback data exchange scenario was considered. The three demonstration parts are a Contoured Skin Laminate (CSL), Core Stiffened Panel (CSP), and "T"-Composite Assembly (TCA). The value represents labor hours to perform the life-cycle tasks. The table shows the hours it takes today (AS-IS) to perform the tasks and the hours it is estimated to take when the application protocols are implemented (TO-BE).

Table 1 PAS-C AP Suite Implementation

DEMO PART	PAS-C AP SUITE			
	AS-IS	TO-BE	Δ HOURS	REDUCTION
CSL	2184	1811	373	17%
CSP	4401	3623	778	18%
TCA	660	556	104	16%

3 APPLICATION PROTOCOL EXECUTIVE SUMMARY

After the APs were selected, an AP summary sheet was developed to pursue the development of the appropriate new STEP part. The Design <--> Analysis AP analysis was completed first, and the AP summary sheet was submitted to the International Organization for Standardization (ISO) via the IGES/PDES Organization (IPO). The ISO has approved the AP project for the Design to Analysis Application Protocol and has assigned Part number 209 to this application protocol (AP 209). The other AP summary sheets are being worked aggressively with the respective standards organizations (IPO and ISO).

The following three sections provide more details of the APs that are included in the discussed sections. Appendices B, C, and D contain the respective AP summary sheets.

3.1 Design to Analysis

The goal of this AP is to link Design, Finite Element and Detail Structural Analysis applications in a manner that provides a bi-directional information exchange capability.

This AP will address: The transfer of geometry (point, line, curve and surface) information between Design and Analysis applications primarily relying heavily on work from APs 201 through 205 as appropriate; specialized composite data such as contiguous ply boundaries, ply stacking sequence and ply fiber orientation angle(s); finite element (FE) mesh, loads, and boundary conditions, analysis controls, and a common analysis output data format for FE and Detail (such as panel buckling or joints) linear static structural and thermo-structural analyses.

The analysis of metallic structures will be within scope as homogeneous metallic material response is a subset of anisotropic composite material response. The material response description and the lack of specialized composite information are the only major differences between composite and metallic structural analyses.

3.2 Design to Manufacturing

The goal of this application protocol is to link Design to Manufacturing for aerospace composite structural parts.

This AP will address: The transfer of complete product definition of a composite structural part from design to manufacturing. Included is the shape defined in 3-D geometry, configuration control information, as well as definition of specialized composite data such as ply boundaries, ply stacking sequence, ply fiber orientation, and core stiffener definitions. The primary focus of this AP will be the exchange of data between design and tool design. This AP will also address the exchange of information between the various functions within Manufacturing Engineering such as process planning, and NC programming where appropriate. It excludes information which is furnished to manufacturing in specific protocols such as APT or Complete Process plans. Documentation generated in manufacturing such as inspection and as-built documentation is also excluded.

3 Design to Support

This Application Protocol will support the presentation of composite parts (as stated above) product shape by 2D geometric views that are related to one another or when possible to a 3D geometric representation. The annotation (eg. tolerances, callouts, etc) of the 2D geometric views are defined in the respective 2D view and may or may not be directly related to the 2D (or the 3D) geometric representation. The bill of materials and configuration information will be maintained within the product structure representation. This information will be presented in a 2D view and will not be directly related to the shape information contained within the respective geometric representation(s). The composite information that is typically represented in ply tables (e.g. ply diagrams, etc) are inter-related and can be cross-referenced.

The data consists of aircraft composite structural parts such as a core stiffened panel, contoured skin laminate, and a T-composite assembly. The AP will build upon the functionality of AP 201 (Explicit Draughting), AP 202 (Associative Draughting), and AP 203 (Configuration Controlled Design) because of the applicability of these STEP Parts.

The functional requirements for this Application Protocol have been derived from requirements defined in the Needs Analysis of the PAS-C Program, MIL-T-31000 (Technical Data Packages, General Specification For) Requirements, the Computer-Aided Acquisition and Logistic Support (CALS) Product Definition Data (PDD) Current Environment Report, the Depot Support Requirements Document, and the F-22 Program during the Digital Product Models Program. The PDES Application Protocol Suite for Composites (PAS-C) Program and other appropriate parties will continue to refine the scope and requirements until the Application Protocol development start date.

4 PROGRAM SUCCESS CRITERIA

The PAS-C Success Criteria was derived from the Air Force's programs objectives. How well each objective is met will define how successful the program is. The purpose of this section is to establish some measurable criteria that will help guide and prioritize PAS-C tasks and deliverables over the duration of the PAS-C Program.

For the PAS-C program the overall objectives were defined by the Air Force. A summary of those objects with their corresponding success criteria follows.

The priority of the objectives follow in the order they appear with the first objective being the most important. Many interrelationships exist between the stated objectives. Therefore, addressing an aspect of one objective might satisfy a portion of another. PAS-C will attempt to complete all objectives to the highest degree and select tasks that satisfy the most objectives.

Table 2 Program Objectives & Success Criteria

MAJOR OBJECTIVES	SUCCESS CRITERIA
1 Develop a product definition information model sufficient to represent and exchange information to design, analyze, test, produce, assure the quality of, and repair composite parts as typified by aircraft composite structural components.	**A** How many of the functional areas (e.g., design) did the program address? **B** How well did the information model support the needs of the addressed functional areas? This should be me- ured by the completeness of the data to fully satisfy t- requirements of Level 3 production drawing packages as specified in MIL-T-31000. **C** How well and how many typical aircraft composite structural parts does the information model cover?
2 Demonstrate a product definition information model sufficient to represent and exchange information to design, analyze, test, produce, assure the quality of, and repair composite parts as typified by aircraft composite structural components.	**A** How well does the demonstration show the extent/completeness of the information model? **B** How well does the demonstration show implementation opportunities? (Could be measured by the number of vendors on the VIG and to the number of vendor who participate in the demonstration itself and their level of participation) **C** How clear is the rational for potential cost benefit documented?

MAJOR OBJECTIVES	SUCCESS CRITERIA
3 Initiate and establish the procedures required to provide a neutral data format for composite structures so that the composite product data can be digitally transferred between industry producers and also between these producers and government agencies.	**A** How many different implementation scenarios do the developed APs support? **B** How well are these scenarios documented? (Could be measured by completeness/ useability of the AP users guide and the confidence the Air Force shows by the initiation of these data delivery requirements in their weapon systems contracts.) **C** Do the APs cover transfer between industry partners? **D** Do the APs cover transfer between industry and government agencies? **E** How well do the APs support Integrated Product Development? **F** How well do the APs support reduced product delivery time? **G** Where and how do these APs reduce the cost of Air Force weapon systems?
4 Define the framework for application specific implementation procedures to be used in making the Product Data Exchange using STEP (PDES) specification supportive of the full spectrum of manufactured parts and procedures throughout their product life-cycle.	**A** Was a framework methodology/procedure developed? **B** How successfully was this methodology in developing the AS? **C** Is the methodology extendable to other manufactured parts? If so, to what extent?(what product types and life-cycle functions?) **D** How well is this methodology documented? (Were pit-falls identified and recommended changes documented?) **E** How easy is this methodology to use? **F** Have any other project/organization used this methodology or any portion of the methodology? **G** Has any of this methodology been incorporated into STEP?
5 Promote the growth and maturation of PDES and endorse its use as a national standard.	**A** How many committees did the PAS-C support? (chair, members of) **B** How many STEP models did the AS enhance through use of the part? **C** What type of technology transfer was accomplished? (IPO,ISO, other standards organizations, hardware/software vendor community, composite manufacturing community, potential PDES user community, government agencies, synergism between other on-going programs)

These success criterion have already been factored into the Application Protocol Criteria and will be revisited periodically to ensure that the overall program objectives are met.

5 RESULTS/CONCLUSIONS

The PAS-C Program has evaluated many different life cycle data exchange scenarios for composites and has narrowed the domain down to three Application Protocols. Within each of these three Application Protocols the domain aspects have been prioritized to insure the most beneficial exchanged areas are addressed first. The PAS-C scoping and benefits methodology that arrived at these three Application Protocols takes into consideration many managerial and technical perspectives to arrive at a suite of Application Protocols that can be utilized for data exchange throughout the life cycle of a composite item. In this, the PAS-C Program has attempted to balance the needs of industry and business against the environment that exists within the STEP development community and the available PAS-C resources. The three Application Protocols that are recommended for development in the next phase of the PAS-C Program were outlined during the analysis and have been augmented to be:

- Design to Analysis: Appendix B - Design through Analysis of Composite and Metallic Structures,
- Design to Manufacture: Appendix C - Exchange of Product Design Data from Design to Manufacturing for Composite Structures,
- Design to Support: Appendix D - Exchange of Engineering Release Data for Aircraft Composite Structural Parts.

These three Application Protocols showed the highest payback with the criteria that the PAS-C Program has developed. The Life Cycle Costs analysis that was run against the demonstration parts did not account for many of the cost items that are very hard to quantify such as: better configuration control, fewer paper requirements, reduction/elimination of lost data, and schedule reduction. Even though these very hard to quantify cost items were not accounted for, the calculated benefit in this document for implementing the PAS-C AP Suite could have been over 1200 hours for the respective PAS-C demonstration parts.

The following list summarizes the data exchanges that were the best candidates for each of the three PAS-C Application Protocols. Each of the data exchanges listed gave a positive return in the life-cycle analysis and were rated most critical by the AP Criteria Analysis. This should ensure that the most important portions of information will be included in each of the APs. (Definitions for the data exchanges are contained in reference [1]).

AP1 - Design to Analysis

1) design modifications/ corrections
2) materials data
3) process data
4) models
5) drawings
6) parts list
7) thermal/moisture data
8) mass properties data
9) loads data

AP2 - Design to Manufacturing

1) drawings
2) parts list
3) part geometry

AP3 - Design to Support

1) models
2) drawings
3) item indenture
4) parts list
5) materials data
6) process data
7) specifications/standards

It is believed that as industry and government move to a more digital data environment, the need for digital data exchange capabilities will increase. The digital environments of today are finding that as systems are implemented to automate processes, one of the prime labor drivers is in the movement of data between the systems. Thus the implementation of digital data exchange capabilities that PAS-C fosters will drive down overall costs for systems implementation. PAS-C will be one of the first Programs that has taken a life cycle approach to the data exchange issue by placing emphasis on utilizing the same underlying data structure to exchange data.

The key to integrated, automated (automation) processes is a robust digital product definition that the downstream user can utilize. **Automated, Integrated Processes are the Key to being Cost Effective.**

REFERENCES

1. Functional Needs IDEF0 Activity and Information Models for the PAS-C Program, Document No. PASC006.01.00, 9 January 1992.

2. PAS-C Sample Part Set, Document No. PASC003.01.00, 30 September, 1991.

3. Development and Demonstration Plan for the PAS-C Program, Document No. PASC010.01.00, 28 May, 1992.

4. Functional Needs Report for the PAS-C Program, Document No. PASC002.01.00, 30 September, 1991

5. PDES State-of-the-Art Assessment for the PAS-C Program, Document No. PASC005.01.00, 23 December 1992.

APPENDICES

APPENDIX A - PAS-C Related Documents

Program Master Plan for the PAS-C Program, Document No. PMG001.01.00, 30 August, 1991

Functional Needs Report for the PAS-C Program, Document No. PASC002.01.00, 30 September, 1991

PAS-C Sample Part Set, Document No. PASC003.01.00, 30 September, 1991

1991 Annual Report for the PAS-C Program, Document No. PASC004.01.00, 30 September, 1991

PDES State-of-the-Art (SOTA) Assessment for the PAS-C Program, Document No. PASC005.01.00, 23 December, 1991

Functional Needs IDEF0 Activity and Information Models for the PAS-C Program, Document No. PASC006.01.00, 9 January, 1992

Scoping and Benefits Criteria (Volume I - Executive Summary and Overview) for the PAS-C Program, Document No. PASC007.01.00, 14 May, 1992

Scoping and Benefits Criteria (Volume II) for the PAS-C Program, Document No. PASC008.01.00, 14 May, 1992

Functional Needs/State-of-the-Art Comparison for the PAS-C Program, Document No. PASC009.01.00, 28 May, 1992

Development and Demonstration Plan for the PAS-C Program, Document No. PASC010.01.00, 28 May, 1992

Request for PAS-C documentation should be made to WL/MTIB, Wright-Patterson AFB, Ohio 45433-6533

APPENDIX B - Summary Sheet - Design to Analysis

Candidate Application Protocol Summary
January 28, 1992

1. **Application Protocol Title:**

Design through Analysis of Composite and Metallic Structures

2. **Nominator:** Keith Hunten
Chair IPO Finite Element Analysis Committee
Project Leader: ISO TC184/SC4/WG3/P9 Finite Element Analysis

Company: General Dynamics Fort Worth Division
Mail Address: P.O. Box 748, MZ2824
Fort Worth Texas 76101
Telephone (817)-777-2147
Facsimile (817)-777-2115
email fwr441@fin.af.mil

3. **ISO TC184/SC4 representative:** Kal Brauner

4. **Scope and requirements of the AP:**

The goal is to link Design, Finite Element and Detail Structural Analysis applications in a manner that provides a bi-directional information exchange capability.

This AP will address: The transfer of geometry (point, line, curve and surface) information between Design and Analysis applications primarily relying heavily on work from APs 201 through 205 as appropriate; specialized composite data such as contiguous ply boundaries, ply stacking sequence and ply fiber orientation angle(s); finite element (FE) mesh, loads, and boundary conditions, analysis controls, and a common analysis output data format for FE and Detail (such as panel buckling or joints) linear static structural and thermo-structural analyses.

The analysis of metallic structures will be within scope as homogeneous metallic material response is a subset of anisotropic composite material response. The material response description and the lack of specialized composite information are the only major differences between composite and metallic structural analyses.

The PDES Application Protocol Suite for Composites (PAS-C) program, with the aid of any interested parties, will continue to refine the scope and requirements until the June 1992 AP development starting date.

5. **Application Activity Model:**

The foundations for the AAM have been prepared in the following reports: PASC002.01.00 - Functional Needs Report for the PAS-C Program, and PASC006.01.00 Functional Needs IDEF0 Activity and Information Models for the PAS-C Program.

6. **Evidence of industry need for AP:**

The concurrence of the members of the IPO Composites committee, the IPO FEA committee, and the ISO FEA project (WG3/P9), and the existence of the PAS-C contract let by the Air Force Systems Command Department of the Air Force Wright Patterson AFB. The members of the PAS-C team and the above committees and project represent a broad cross-section of industry.

7. **Summary of industry review(s) of the scope and requirements:**

The PAS-C Industry Review Board (IRB) January 9, 1992, the IPO FEA committee and ISO FEA project concluded that the scope as it has been developed to date is sufficient to proceed with the initiation of this AP. Further PAS-C IRB, IPO, and ISO reviews of the scope and requirements will be held. As mentioned in item 4 above, the PAS-C program will continue to coordinate the refinement of the scope and requirements until the June 1992 AP development starting date.

8. **Overlap and relationships to other APs or AP projects:**

This AP will force the issues of defining relationships necessary to unify the views of Product Data within and between Analysis and Design. This integration of Product Data will be performed to a degree necessary to accommodate the goal of this AP. Issues of relationships to Parts, APs, and between APs need to be addressed. The PAS-C Framework/Building-Block (FW/BB) approach is a critical tool to accomplish this task, along with other methodologies under development by the AP Framework committee. An initial assessment of the APs that will be required include 203, 204, 205, and a potential FEA Materials AP.

9. **Status of the required resource models:**

The PAS-C State of the Art Assessment of STEP (PASC005.01.00) concludes that the STEP Parts and APs are or will be developed to an acceptable level within the timespan of the development of this AP. An initial assessment of the Parts that will be required include 41 through 45, and 104.

10. Current participants and committed resources for developing the AP:

Keith Hunten will lead the PAS-C team which will provide the primary resources for the development of this AP. The PAS-C program is funded for 25.9 man-years over four years to develop and demonstrate this and two other APs.

Individuals in the countries of the UK, Norway, and Sweden have tentatively agreed to provide resources to comment and review the AP work as it progresses.

11. Schedule for delivering AP with existing resources:

June 1992 start, final delivery June 1994.

APPENDIX C - Summary Sheet - Design to Manufacturing

DRAFT - April 6, 1992

Proposed Application Protocol Summary Sheet

1. **Proposed AP Title:**

Exchange of Product Design Data from Design to Manufacturing for Composite Structures.

2. **Nominator:** Floyd Ganus, PAS-C
Company: LTV Aerospace & Defense Co.
Mail Address: P.O.Box 655907, M.S. 49R34
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3. **ISO TC184/SC4 Representative:** Kal Brauner
Company: Boeing Commercial Airplane
Mail Address: P.O. Box 3707
MS 6A-WA
Seattle, WA 98124
Telephone: (206) 234-8580
Facsimile: (206) 234-5775
E-Mail: kbrauner@mcimail.com

4. **Scope and Functional Requirements of the AP:**

The goal is to link Design to Manufacturing for Aerospace composite structural parts.

This AP will address: The transfer of complete product definition of a composite structural part from design to manufacturing. Included is the shape defined in 3-D geometry, configuration control information, as well as definition of specialized composite data such as ply boundaries, ply stacking sequence, ply fiber orientation, and core stiffener definitions. This AP will also address the exchange of information between the various functions within Manufacturing Engineering such as process planning, tool design, and NC programming. It excludes information which is furnished to manufacturing in specific protocols such as APT or Complete Process plans. Documentation generated in manufacturing such as inspection and as-built documentation is also excluded.

5. **Application Activity Model:**

The foundations for the AAM have been prepared in the following reports:

PASC002.01.00 - Functional Needs Report for the PAS-C Program, and PASC006.01.00 - Functional Needs IDEF0 Activity and Information Models for the PAS-C Program.

6. **Evidence of industry need for AP:**

The concurrence of the members of the IPO Composites Committee, the IPO Manufacturing Technology Committee, and the existence of the PAS-C contract by the Air Force Systems Command Department of the Air Force Wright Patterson AFB. The continuing growth of composite structure within the aerospace industry and the many efforts to lower composite part manufacturing costs.

7. **Summary of Industry Review(s) of the Scope and Functional Requirements:**

The PAS-C Industry Review Board (IRB) January 9, 1992 felt that the scope as it has been developed to date is sufficient to proceed with the initiation of this Application Protocol. Further PAS-C IRB and IPO/ISO reviews of the scope and requirements will be held.

8. **Overlap and Relationships to Other APs or AP Projects:**

This Application Protocol will be related to AP 203 since it will use configuration managed 3-D Product Design Data. It will extend this to specific information for composite parts. It is related to AP 209 in that it shares much of the composite part definition contained it that AP. It extends this information significantly in that it allows definition of internal make-up of a composite part complete enough that it can be manufactured.

AP PART NO.	STEP AP Part Title	Relationship
203#	Exchange of Configuration Controlled 3-D Product Design Data	
205*	Exchange of Sculptured Surface Models	
206	Mechanical Design Using Wireframe	
207	Design Data for Development of Sheet Metal Dies & Blocks	
208*	Life Cycle Product Change Process	
209*	Design through Analysis of Composite & Metallic Structures	

KEY

= Strong Relationship
* = Portions May or May Not Apply

9. Status of the Required Resource Models:

The PAS-C State of the Art Assessment of STEP concludes that the STEP Resource Model Parts are or will be developed to an acceptable level within the timespan of the development of this Application Protocol. The initial assessment of the Resource Models are as follows in the following table:

Part No.	STEP Part Title	Status
41#	Fundamental of Product Description and Support "Framework"	
42#	Geometric and Topological Representation	
43#	Representation Structures	
44#	Product Structure Representations	
45#	Materials	
47*	Shape Variation Tolerances	
48*	Form Features	
10x#	Composites Resources	

10. Current Participants and Committed Resources for Developing the AP:

Floyd Ganus will lead the PAS-C team which will provide the primary resources for the development of this Application Protocol. The PAS-C program is funded for 25.9 man-years over four years to develop and demonstrate this and two other Application Protocols.

11. Schedule for delivering AP with existing Resources:

TBD

APPENDIX D - Summary Sheet - Design to Support

DRAFT - February 27, 1992

Proposed Application Protocol Summary Sheet

1. **Proposed AP Title:**

Exchange of Engineering Release Data for Aircraft Composite Structural Parts.

2. **Nominators:**

Nominators:	Jody M. Anderson	Glen Ziolko
Company:	Boeing	SCRA
Mail Address:	P.O. Box 24346 MS 4C-75 Seattle, WA 98124	700 Highlander Blvd Suite 150 Arlington, TX 76015
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Facsimile:	(206) 662-0090	(817) 472-8723
E-Mail:	jody@asw1.boeing.com 0005156353@mcimail.com	0004863474@mcimail.com

3. **ISO TC184/SC4 Representative:**

ISO TC184/SC4 Representative:	Kal Brauner
Company:	Boeing Commercial Airplane
Mail Address:	P.O. Box 3707 MS 6A-WA Seattle, WA 98124
Telephone:	(206) 234-8580
Facsimile:	(206) 234-5775
E-Mail:	kbrauner@mcimail.com

4. **Scope and Functional Requirements of the AP:**

This Application Protocol will support the presentation of composite parts product shape by 2D geometric views that are related to one another or when possible to a 3D geometric representation. The annotation (eg. tolerances, callouts, etc) of the 2D geometric views are defined in the respective 2D view and may or may not be directly related to the 2D (or the 3D) geometric representation. The bill of materials and configuration information will be maintained within the product structure representation. This information will be presented in a 2D view and will not be directly related to the shape information contained within the respective geometric representation(s). The composite information that is typically represented in ply tables (e.g. ply diagrams, etc) are inter-related and can be cross-referenced.

The data consists of aircraft composite structural parts such as a core stiffened panel, contoured skin laminate, and a T composite assembly. The AP will build upon the functionality of AP 201, AP 202, and AP 203 because of the applicability of these STEP Parts.

The functional requirements for this Application Protocol have been derived from requirements defined in the Needs Analysis of the PAS-C Program, MIL-T-31000 (Technical Data Packages, General Specification For) Requirements, the Computer-Aided Acquisition and Logistic Support (CALS) Product Definition Data (PDD) Current Environment Report, the Depot Support Requirements Document, and the F-22 Program during the Digital Product Models Program. The PDES Application Protocol Suite for Composites (PAS-C) Program and other interested parties will continue to refine the scope and requirements until the Application Protocol development start date.

5. Preliminary Application Activity Model (AAM) for the AP:

The AAM for AP 201, AP 202 and AP 203 are available and will be the baseline for development of the PAS-C AAM. Preliminary scoping and activity models have been created for the PAS-C program. The appropriate portions of the STEP AAMs and the PAS-C Activity Models will be consolidated into a single AAM for PAS-C.

6. Evidence of Industry Need for the AP:

Several Programs have identified the need for an AP that can be used to exchange this type of information. To name some of the more recent activities: PAS-C, Depot Support Requirements Document (DSRD), CALS Product Definition Data (PDD) Current Environment Report, ATF Digital Product Models (DPM) Program, F-22 Digital Product Definition (DPD) Data Program and a European effort to produce a fighter involving at least 4 countries, England, Spain, Germany and Italy (EFA).

7. Summary of Industry Review(s) of the Scope and Functional Requirements:

The PAS-C Industry Review Board (IRB) January 9, 1992 felt that the scope as it has been developed to date is sufficient to proceed with the initiation of this Application Protocol. Further PAS-C IRB and IPO/ISO reviews of the scope and requirements will be held. As mentioned in item 4 above, the PAS-C effort will continue to refine the scope and requirements until the Application Protocol development start date.

8. Overlap and Relationships to Other APs or AP Projects:

This Application Protocol will address the issues of defining the product shape, bill of materials and drafting information into a single view of Product Data. This will necessitate the integration of STEP Drafting efforts and Product Structure/Configuration Management to a degree necessary to accommodate the goal of this Application Protocol. The PAS-C Framework/Building-Block (FW/BB) approach is a critical tool to accomplish this task, along with other methodologies under development by the Application Protocol Framework committed. The relationship to existing STEP Application Protocols is defined in the following table:

AP Part No.	STEP AP Part Title	Relationship
201#	Exchange of Explicit Draughting	Exchange of Explicit Draughting as it applies to Composites Design, Analysis and Manufacturing when association with 3-D geometry is not supported.
202#	Exchange of Draughting with 3-D Geometry	Exchange of Draughting with 3-D Geometry as it applies to Composites Design, Analysis and Manufacturing Data.
203#	Exchange of Configuration Controlled 3-D Product Design Data	Exchange of Configuration Controlled 3-D Product Design Data as it applies to Composites Design, Analysis and Manufacturing Data.
204*	Exchange of Boundary Representation Solid Models	As necessary to support the Design, Analysis and Manufacturing functions.
205*	Exchange of Sculptured Surface Models	As necessary to support the Design, Analysis and Manufacturing functions.
206*	Mechanical Design Using Wireframe	As necessary to support the Design, Analysis and Manufacturing functions.
207*	Design Data for Development of Sheet Metal Dies & Blocks	TBD
208*	Life Cycle Product Change Process	TBD

Key

\# = Strong Relationship
* = Portions May or May Not Apply

9. Status of the Required Resource Models:

The PAS-C State of the Art Assessment of STEP concludes that the STEP Resource Model Parts are or will be developed to an acceptable level within the timespan of the development of this Application Protocol. The initial assessment of the Resource Models are as follows in the following table:

Part No.	STEP Part Title	Status
41	Fundamentals of Product Description and Support "Framework"	TBD
42#	Geometric and Topological Representation	TBD
43#	Representation Structures	TBD
44#	Product Structure Representation	TBD
45	Materials	TBD
46#	STEP Presentation	TBD
47*	Shape Variation Tolerances	TBD
101#	Draughting Resources	TBD
10X	Composites Resources	TBD

Key

= Strong Relationship
* = Portions May or May Not Apply

10. Current Participants and Committed Resources for Developing the AP:

Jody Anderson will lead the AP Team which will provide the primary resources for the development of this Application Protocol. The PAS-C program is funded for 25.9 man-years over four years to develop and demonstrate this and two other Application Protocols.

It is anticipated that the next logical progression in the STEP development will be the merging of the requirements in AP 201, AP 202, and AP 203.

11. Schedule for delivering AP with existing Resources:

TBD

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